

# Morphological Variations of Male Genitalia in Northeast Asian Wood-eating Cockroaches, *Cryptocercus* spp. (Insecta: Blattodea)

Yung Chul Park<sup>1</sup>, Joo-Pil Kim<sup>2</sup> and Jae Chun Choe<sup>3,\*</sup>

<sup>1</sup>Research Institute of Natural History, Ewha Womans University, Seoul 120-750, Korea

<sup>2</sup>Department of Biology, Dongguk University, Seoul 100-715, Korea

<sup>3</sup>Department of Life Science, Ewha Womans University, Seoul 120-750, Korea

## ABSTRACT

Subsocial woodroaches of *Cryptocercus* occur in high mountainous forests in temperate regions and they live in a family in complicated galleries of rotten logs. A prominent feature of the geographical distribution of *Cryptocercus* is the wide disjunction between the eastern and western species in North America, and between West China and Northeast Asia. Recently, five species of the genus were added from Asian areas and two of them are distributed in Northeast Asian areas. We examined morpho-anatomical structures of male genitalia in Manchurian and Korean *Cryptocercus*, focusing on male genital hooks and subgenital plates.

**Key words:** Genitalia, *Cryptocercus*, genital hook, subgenital plate

## INTRODUCTION

Woodroaches of *Cryptocercus*, which are well known because of their peculiar life historical characteristics, occur in high mountainous forests in temperate regions. *Cryptocercus* cockroaches, subsocial and xylophagous insects, live in a family in complicated galleries of rotten logs (Cleveland et al., 1934; Seelinger and Seelinger, 1983; Nalepa, 1984; Grandcolas et al., 2001; Park et al., 2002).

Distribution of the genus *Cryptocercus* are the wide disjunctive between the eastern and western species in North America, between the Nearctic and the Palearctic species, and between populations of West China and Northeast Asia including Manchuria, the Ussuri and Siberia of Russia and South Korea (Scudder, 1862; Bey-Bienko, 1935, 1950; Clark et al., 2001).

There are currently 12 species recognized in *Cryptocercus*, including five species in the Palearctic (Bey-Bienko, 1950; Grandcolas, 2000; Grandcolas et al., 2001, 2005; Nalepa et al., 2001) and five species in the Nearctic (Nalepa et al., 1997; Burnside et al., 1999) regions. In the Palearctic species, *C. primaries*, *C. matilei*, *C. hirtus* and *C. meridianus* are found in West China (Bey-Bienko, 1950; Grandcolas, 2000; Grandcolas et al., 2005). *Cryptocercus kyeabangensis* is an endemic species to South Korea (Grandcolas et al., 2001). Manchurian *Cryptocercus* was known as same species with *C. relictus* in Russia (Bey-Bienko, 1950). In a recent study

(Grandcolas et al., 2005), however, the Manchurian *Cryptocercus* was renamed as *C. parvus*, a different species from that of Siberia (Grandcolas et al., 2005).

According to a recent study on the biogeography and phylogenetic relationships among Northeast Asian *Cryptocercus*, based on the DNA sequences of mitochondrial COII and 16S rRNA genes and nuclear 18S rRNA gene, Korean *Cryptocercus* cockroaches were separated from Manchurian *Cryptocercus*. In addition, Manchurian *Cryptocercus* was a little different from Siberian *Cryptocercus* (Park et al., 2004).

In this study, we examined morpho-anatomical structure of male genitalia, focusing on genital hooks, and we also examined morphological variations of male subgenital plates.

## MATERIALS AND METHODS

Woodroaches of *Cryptocercus* were collected from Northeast Asia, that is, Manchuria in China and South Korea, as well as those from North America. *Cryptocercus* from South Korea were collected during June 2001. *Cryptocercus* from Northeast China were collected during October 1998. Extensive field samplings have shown that *Cryptocercus* populations exist in most of the mountainous regions from the North (Seorak-san) to the South (Jiri-san) of South Korea. All of the collection localities are connected to the Taebaek Mountains, which is present along the eastern part of South Korea from the North to the South. Information of sampling localities is shown in Table 1.

\*To whom correspondence should be addressed

Tel: 82-2-3277-4511, Fax: 82-2-3277-4513

E-mail: jaechoe@ewha.ac.kr

For the examination of genital structure, dissection of a male genital apparatus was conducted in 100% alcohol, and all parts of the genital apparatus were examined under a microscope (Olympus SZ STB1). Subgenital plates of *Cryptocercus* males were analyzed using scanning electron microscopy (SEM). For the SEM analyses, the subgenital plates were fixed for 1 h in 2.5% glutaraldehyde in 0.1 M phosphate buffer, washed in the buffer, postfixed for 1 h in 2% osmium tetroxide in the same buffer, and dehydrated in a graded series of ethanol solutions. Specimens were mounted on stubs, coated with gold using an ion coater (Eiko Model IB-3), and examined with an SEM (Akashi Model SR 50A)

operated at an accelerating voltage of 15 KV. Male genital hooks were also examined in *Cryptocercus* spp. The SEM examinations for the genital hooks were conducted according to the same procedures above.

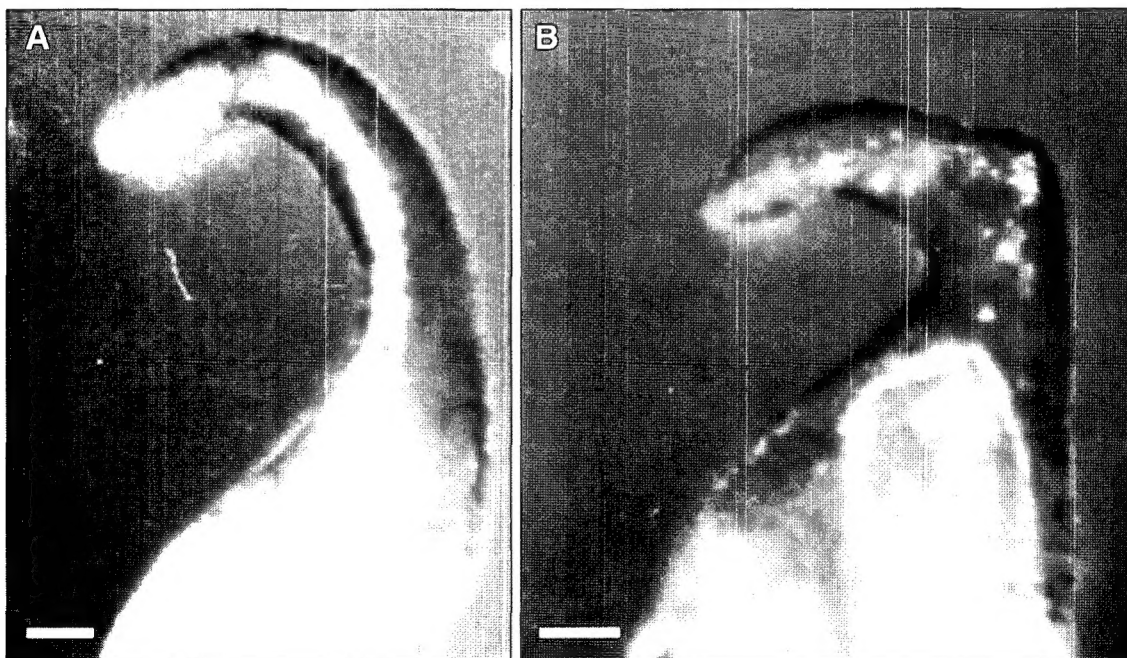
## RESULTS AND DISCUSSION

### Morphological structure of *Cryptocercus* male genitalia

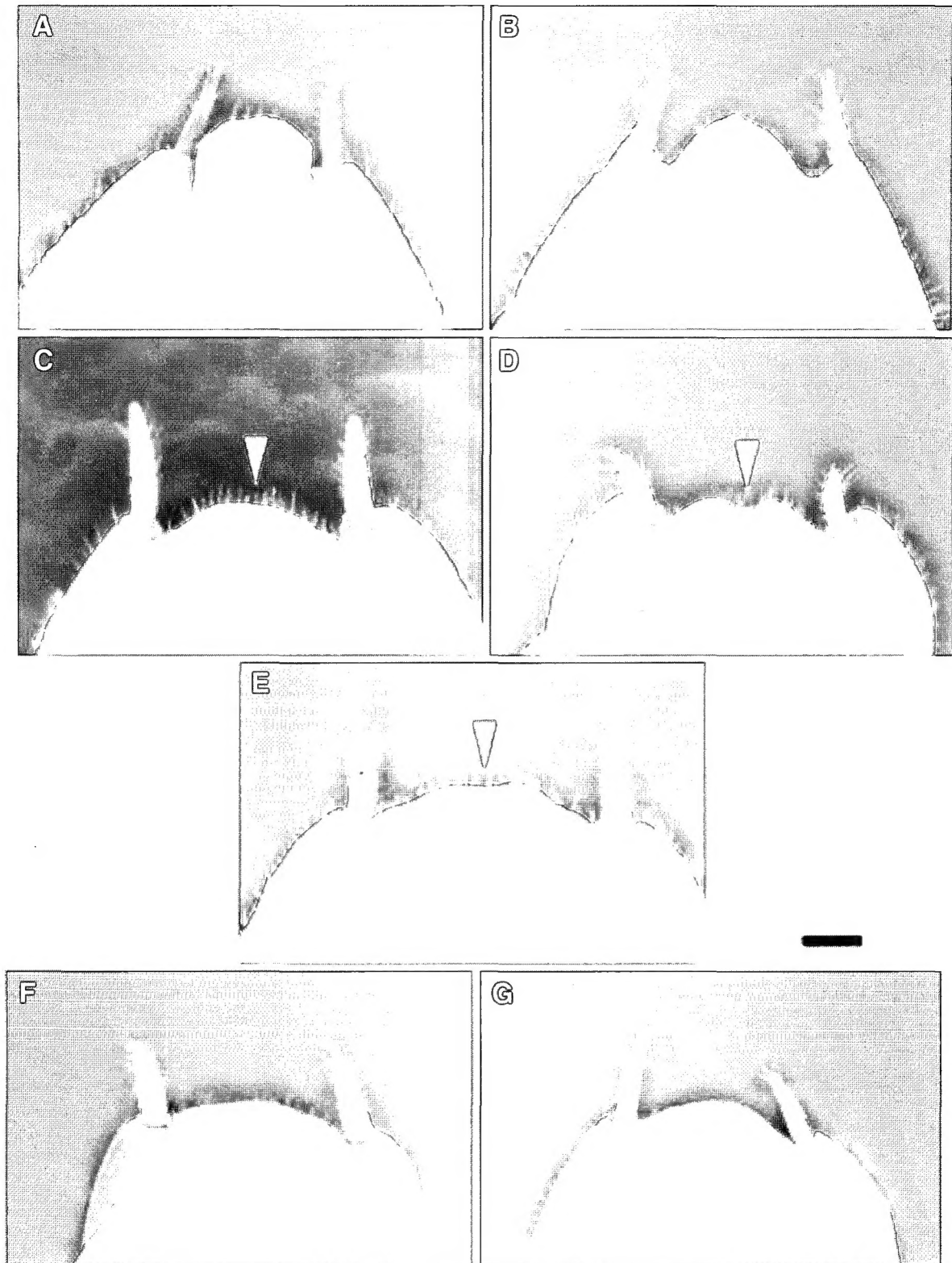
The genital apparatus of *Cryptocercus* male comprises three phallomeres of the right- and the left phallomere and

**Table 1.** List and sampling localities of *Cryptocercus* spp. used in this study

Species	Sampling location	Abbreviation of location	No. of samples
<i>C. kyebangensis</i> (GYEB)	Gyebang-san (1,577 m), Gangwon Province, South Korea	GYEB	6
<i>C. kyebangensis</i> (JUWA)	Juwang-san (=Juwangsan Natl. Park, 720 m), Gyongsang Province, South Korea	JUWA	4
<i>C. kyebangensis</i> (JIRI)	Jiri-san (=Jiri-san Nat. Park, 1,915 m), Jolla Province, South Korea	JIRI	1
<i>C. parvus</i> (XING)	Laoheidingzi (1,349 m) near Xingnong Linchang (= tree farm), 64 km W-SW Hailin city, China	XING	4
<i>C. parvus</i> (MUDA)	Tian-shan (=Tian Ling, or Mudanfeung) (1,115 m), 32 km western side of Ningan city, China	MUDA	6
<i>C. punctulatus</i> (ENA)	Eastern North America	ENA	1
<i>C. clevelandi</i> (WNA)	Western North America	WNA	1



**Fig. 1.** Comparison of male genital hooks in two Northeastern *Cryptocercus* species (A: *C. parvus*, B: *C. kyebangensis*). Scale bars=0.143 mm.



**Fig. 2.** Morphology of male subgenital plates. *Cryptocercus clevelandi* (A), *C. punctulatus* (B), *C. parvus* (XING) (C) and *C. parvus* (MUDA) (D) from Northeast China, *Cryptocercus* sp. (JIRI) (E) from Jiri-san, *C. kyebangensis* (GYEB) (F) from Gye-bang-san, and *C. kyebangensis* (JUWA) (G) from Juwang-san. *Cryptocercus* (C, D) from Northeast China and that (E) of Jiri-san show the similarity of morphology in the areas indicated by arrows. Scale bar=0.4 mm. See Table 1 for each locality and abbreviation.

hypophallus. The genital hook is one of three horned processes which lie on the left phallomere, and it is mostly curved outwards. In *Cryptocercus kyebangensis*, mating is in the end-to-end position (unpublished data). Thus, function of the male genital hooks appears to grasp the female's genital opening, though its function needs to be more investigated. Examinations under a microscope showed that the hook morphology was a little different between *C. parvus* and *C. kyebangensis* (Fig. 1). In *Cryptocercus parvus*, the warped portion of the genital hook is simple elongate, slender, highly narrowed toward the apex from base, and smoothly curved near its apical portion, resulting in the morphological shape like hook, while *C. kyebangensis* has a shorter and stouter genital hook, with the apex strong and more sharply curved.

#### Morphological variations of male subgenital plates in *Cryptocercus* spp.

The male subgenital plate of western North American species, *C. clevelandi*, had a broadly rounded caudal margin between the base of the styli (Fig. 2A), but was more narrowly rounded in eastern North American species, *C. punctulatus* (Fig. 2B). Both of the North American species could be discriminated from Northeast Asian populations by a more protruding caudal margin.

In the populations from Northeast China, there were two types of the subgenital plate. One type had a somewhat slightly emarginated middle in the rounded caudal margin (Fig. 2C), while the other type was emarginated more deeply in the middle area of the caudal margin (Fig. 2D). *Cryptocercus* from Northeast China had more protruded caudal margin and more convex morphology of their caudal margin than all Korean *Cryptocercus* (Fig. 2F and G) except populations (2E) from Jiri-san. In the Korean populations, with the exception of *Cryptocercus* from Jiri-san, the male subgenital plates were evenly rounded (Fig. 2F), or very slightly protruding in the middle of the caudal margin between the styli (Fig. 2G). The subgenital plate of *Cryptocercus* males (Fig. 2E) in Jiri-san, however, might appear to be a more similar to those from Northeast China than the other Korean *Cryptocercus* (Fig. 2F and G). Since we examined the structure of only one male individual from Jiri-san, further investigations need to be conducted.

#### CONCLUSIONS

In the comparisons of the subgenital plates, morphological differences of the plates were a little ambiguous between the two Northeast Asian species as well as within Korean populations, but well discriminated between the two North

American species.

The whole body appearance was very similar in the woodroaches of *Cryptocercus* from various local regions from the morphological and anatomical points of view. *Cryptocercus* cockroaches live in cryptic living and the environments of their living habitats are limited to humid rotten logs in high forest mountains. Regardless of their wide disjunctive distributions, similarity of the microclimate environment in woody galleries has influenced conservatively in divergence in *Cryptocercus* body appearance.

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